CLAIM AMENDMENTS

This Listing of Claims replaces all prior versions and listings of claims in the application.

Claim 1 (previously presented) A system for modeling macrostructural characteristics of a bone comprising:

a first hierarchical order comprising at least one macroscopic region of the bone,

a second hierarchical order comprising at least one empirically-derived non-homogeneous second order component representing one or more osteons, trabeculae, or lamellae within the macroscopic region, and

a viscoelastic property correlated with at least one second order component, and

wherein the second order components are used to determine properties of the first hierarchical order region, and

wherein a property of the first hierarchical order region is determined based on the viscoelastic property of the second order component.

Claim 2 (previously presented) A system of claim 1, wherein the osteon is an extinct osteon or an alternate osteon.

Claim 3 (previously presented) A system of claim 1, wherein the viscoelastic property comprises at least one parameter selected from the group consisting of collagen content, mucopolysaccharide content, hydroxyapatite content, osteocyte content, osteoblast content, and content of porosity fluids.

Claim 4 (canceled)

Claim 5 (previously presented) A system of claim 1, wherein the viscoelastic property is selected from the group consisting of an angle-of-twist as a function of torque, osteon hydroxyapatite content, strain rate, and time.

Claim 6 (previously presented) A system of claim 5, wherein the angle-of-twist as a function of torque is derived from tests conducted under monotonic or dynamic loading.

Claim 7 (previously presented) A system of claim 5, wherein angle-of-twist as a function of torque at an approximately constant strain rate and approximately constant hydroxyapatite content is represented by a Ramgood-Osgood equation.

Claim 8 (previously presented) A system of claim 7, wherein a higher hydroxyapatite content leads to a higher angle-of-twist as a function of torque.

Claim 9 (previously presented) A system of claim 7, wherein a higher strain rate leads to a higher angle-of-twist as a function of torque.

Claim 10 (previously presented) A system of claim 1, comprising the viscoelastic properties of extinct and alternate osteons.

Claim 11 (previously presented) A system of claim 10, further comprising a third hierarchical order comprising at least one third order component representing one or more collagen bundles, hydroxyapatite crystallites, mucopolysaccharides, or combinations thereof within one or more regions of the second order components, wherein the third order components are used to construct the second order components;

wherein the viscoelastic properties comprise at least one parameter selected from the group consisting of collagen content, mucopolysaccharide content, and hydroxyapatite content.

Claim 12 (previously presented) A system of claim 11, wherein the ratio of collagen and mucopolysaccharides in extinct osteons as compared to collagen and mucopolysaccharides in alternate osteons is less than 1 for extinct and alternate osteons with approximately equal hydroxyapatite contents.

Claim 13 (previously presented) A system of claim 1, wherein at least one of the osteons has an internal diameter of less than or equal to 40 μm, an external diameter of less than or equal to 210 μm, and a height of less than or equal to 500 μm.

Claim 14 (previously presented) A system of claim 13, wherein at least one of the osteons is an extinct osteon comprising at least 12 laminae.

Claim 15 (previously presented) A system of claim 13, wherein at least one of the osteons is an alternate osteon comprising at least 36 laminae.

Claim 16 (previously presented) A system of claim 1, comprising a Finite Element Model (FEM).

Claim 17 (currently amended) A method of producing a model of bone, comprising the steps of:

a) specifying a first hierarchical order macroscopic region of a selected bone;

b) dividing the macroscopic region into a finite number of elements of a second hierarchical order, each element representing ~~empirically-derived~~ an empirically-derived non-homogeneous second order component comprising one or more osteons, trabeculae, or lamellae;

c) assigning a viscoelastic property to at least one second order component; and

d) determining a property of the first hierarchical order macroscopic region of the selected bone based on the viscoelastic property of the second order component.

Claim 18 (previously presented) The method of claim 17, wherein the model simulates fracture propagation by:

calculating a stress distribution as a function of a torque applied to the bone;

calculating a strain distribution based on the stress distribution; and

comparing strain in the strain distribution to a maximum strain,

wherein fracture occurs when the strain exceeds the maximum strain.

Claim 19 (canceled)

Claim 20 (previously presented) A method of claim 17, comprising the step of determining viscoelastic properties of alternate and extinct osteons.

Claim 21 (previously presented) The method of claim 20, comprising the step of dividing each second order component into a finite number of elements, each element representing one or more collagen bundles, hydroxyapatite crystallites, mucopolysaccharides, or combinations thereof;

wherein the viscoelastic properties comprise at least one parameter selected from the group consisting of collagen content, mucopolysaccharide content, and hydroxyapatite content.

Claim 22 (previously presented) The method of claim 21, wherein the viscoelastic properties are determined by evaluating at least one parameter selected from the group consisting of angle-of-twist as a function of torque, osteon hydroxyapatite content, strain rate, or time.

Claim 23 (previously presented) The method of claim 31, wherein the viscoelastic properties comprise angle-of-twist as a function of torque and the experimental determinations further comprise:

applying quasi-static torsional loading to rupture each of the samples;

collecting data on torque and angle-of-twist of each of the samples;

determining a torque vs. angle-of-twist curve for each of the samples based on the collected data; and

determining the angle-of-twist as a function of torque of the second order components of the selected bone based on the torque vs. angle-of-twist curve of the samples.

Claim 24 (previously presented) The method of claim 31, wherein the samples comprise a plurality of alternate and extinct osteons, and

the method further comprises the steps of:

determining the ratio of collagen and mucopolysaccharides in an extinct osteon of the selected bone as compared to those of an alternate osteon of the selected bone by the following method:

(i) drying the extinct and alternate osteon samples to constant weight;

(ii) separately contacting the extinct and alternate osteon samples with acid to promote the hydrolysis of collagen to hydroxyproline and mucopolysaccharides to hexosamine;

(iii) separating hydroxyproline from hexosamine; and

(iv) determining the ratio of hydroxyproline and hexosamine in the extinct osteon samples as compared to the alternate osteon samples;

wherein the ratio of hydroxyproline and hexosamine in the extinct osteon samples as compared to the alternate osteon samples corresponds to the ratio of collagen and mucopolysaccharides in the extinct osteon of the selected bone as compared to the alternate osteon of the selected bone.

Claim 25 (previously presented) The method of claim 24, wherein the ratio of collagen and mucopolysaccharides in a extinct osteon of the selected bone as compared to an alternate osteon of the selected bone is less than 1 for a extinct and alternate osteon with approximately equal hydroxyapatite contents.

Claim 26 (previously presented) The method of claim 31, wherein the viscoelastic property of the second order components is modified based on collagen-bundle directions of the selected bone, the method further comprising the step of:

determining collagen-bundle directions of the samples using circularly polarizing light microscopy, confocal microscopy or X-ray diffraction of the samples.

Claim 27 (previously presented) A system as in claim 1, wherein the viscoelastic properties of the second order components are assigned based on a plurality of experimental determinations.

Claim 28 (previously presented) A system as in claim 10, wherein each subject bone is divided into a plurality of samples from corresponding locations of each subject bone;

one or more viscoelastic properties of at least one second order component of each sample is evaluated; and

the evaluations are aggregated to determine the viscoelastic properties of the second order components.

Claim 29 (previously presented) A system as in claim 1, wherein the aggregated evaluations are collected in a database of viscoelastic properties for the subject bone of the specified type.

Claim 30 (previously presented) A method of claim 17, wherein the viscoelastic properties of the second order components are assigned based on a plurality of experimental determinations.

Claim 31 (previously presented) A method of claim 30, wherein the experimental determinations comprise the steps of:

selecting a plurality of subject bones of a specified type;

dividing each of the subject bones into a plurality of samples, wherein each sample corresponds to a location within the specified macroscopic region of each subject bone;

evaluating one or more viscoelastic properties of at least one second order component of each sample; and

aggregating the evaluations.

Claim 32 (previously presented) A method of claim 31, wherein the experimental determination further comprises the steps of:

repeating the experimental determination steps for subject bones of different types; and

compiling a database of representative viscoelastic properties of each type of subject bone based on the aggregated evaluations.

Claim 33 (currently amended) A method of producing a model of a bone comprising the steps of:

a) specifying a first hierarchical order macroscopic region of a selected bone;

b) dividing the macroscopic region into a finite number of elements of a second hierarchical order, each element representing ~~empirically-derived~~ an empirically-derived non-homogeneous second order component comprising one or more alternate and extinct osteons;

c) assigning a viscoelastic property to at least one second order component, wherein the viscoelastic property comprises at least one parameter selected from the group consisting of collagen content, mucopolysaccharide content, hydroxyapatite content, osteocyte content, osteoblast content, and content of porosity fluids; and

d) determining a viscoelastic property of the first hierarchical order macroscopic region of the selected bone based on the viscoelastic properties of the second order components.

Claim 34 (previously presented) The method of claim 33, wherein the viscoelastic property of the second order components is modified based on collagen-bundle directions of the selected bone, the method further comprising the step of:

determining collagen-bundle directions of the samples using circularly polarizing light microscopy, confocal microscopy or X-ray diffraction of the samples.

Claim 35 (previously presented) A method of claim 33, wherein the viscoelastic properties of the second order components are assigned based on a plurality of experimental determinations.

Claim 36 (previously presented) A system of claim 11, wherein a relative amount of the third order components depends on degree of calcification of the second order components.

Claim 37 (previously presented) A system of claim 36, wherein the degree of calcification of the second order components is assigned based on experimental determinations.

Claim 38 (previously presented) A method of claim 21, wherein a relative amount of the collagen bundles, hydroxyapatite crystallites, and mucopolysaccharides depends on degree of calcification of the second order components.

Claim 39 (previously presented) A method of claim 38, wherein the degree of calcification of the second order components is assigned based on experimental determinations.